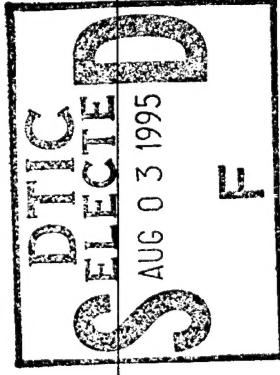




TTC-2583-V
7 December 1992
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Gated Blue Cesium Faraday Atomic Line Filter

**Lasers '92, Houston
8 December 1992**

Prepared by:

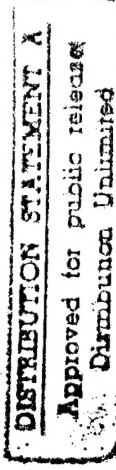
Jim Menders, Paul Searcy, David Ross, Eric Korevaar
ThermoTrex Corporation, San Diego, CA

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Naval Air Warfare Center, Warminster, PA

David Allocca
Ampac, Inc., Warminster, PA

With thanks to:
Craig Howton, ThermoTrex Corporation

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TTC

GATED ULTRA-NARROW MAGNETO-OPTIC ATOMIC LINE FILTERS FOR LIDAR APPLICATIONS

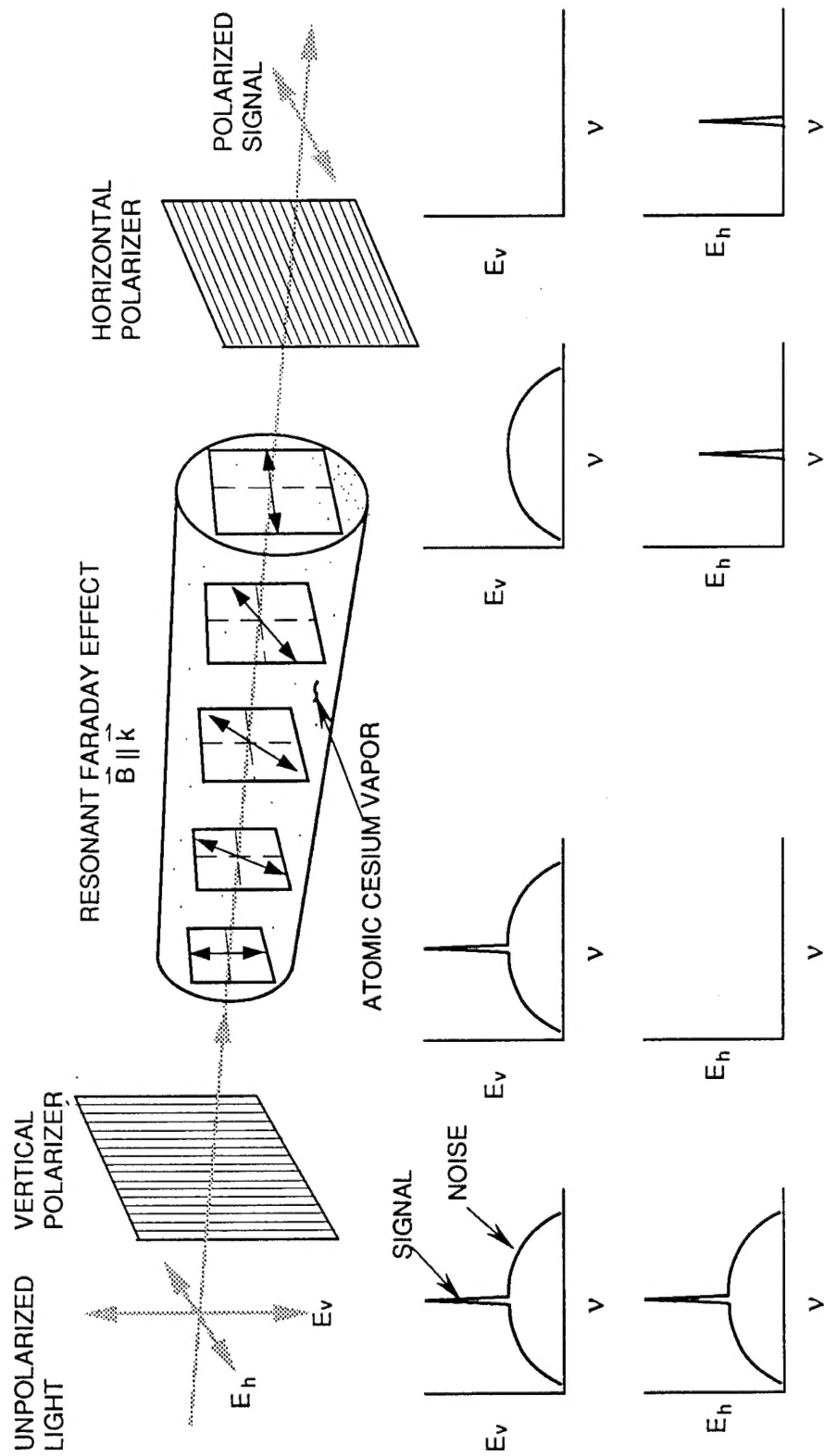
- Solar background limited lidar receivers require ultra-narrow linewidth filters to reach quantum limited operation
 - remote sensing
 - active tracking
- Like the conventional absorptive/re-emissive atomic line filters (ALF), the M-0 ALFs
 - operate at discrete atomic absorption lines
 - have Doppler limited passbands
 - high out-of-band rejection
- However, M-0 ALFs are imaging filters with
 - very high peak transmission
 - wide field-of-view
 - filter bandwidth limited signal bandwidth
- Dynamic range limited receivers benefit from programmable gain to suppress unwanted signals from nearby sources
 - the gated M-0 ALF transmission can be stepped or ramped to reject early signals

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TOPICS

- Principles of Faraday magneto-optic filter operation
- Transmission modulation by field intensity modulation
- Optimizing operating temperature for low field, high transmission
- Pulsed coil design for large ($2''\phi$) aperture filter
- Gated filter tests
- Conclusion

PRINCIPLES OF FARADAY MAGNETO-OPTIC ATOMIC LINE FILTER OPERATION

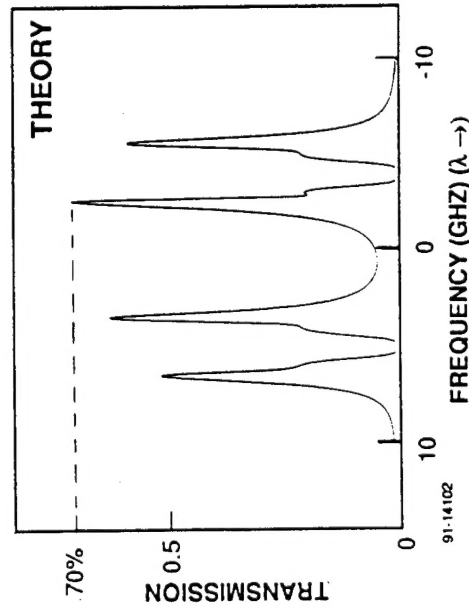
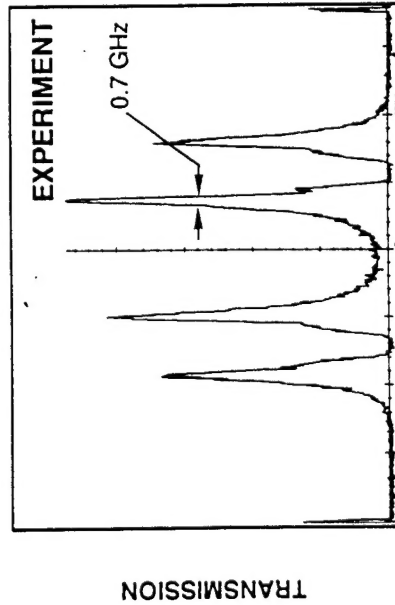


- The magneto-optic element transforms vertical into horizontal polarization over a narrow spectral band
- The resonant Faraday effect is exhibited in near strong absorption lines
- In-band light is transmitted; out-of-band light is blocked
- This work concerns the cesium Faraday filters with resonances at 455 nm and 852 nm

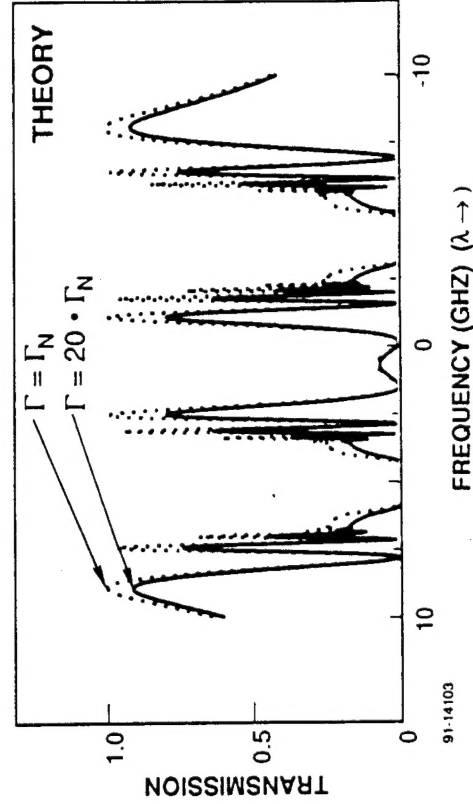
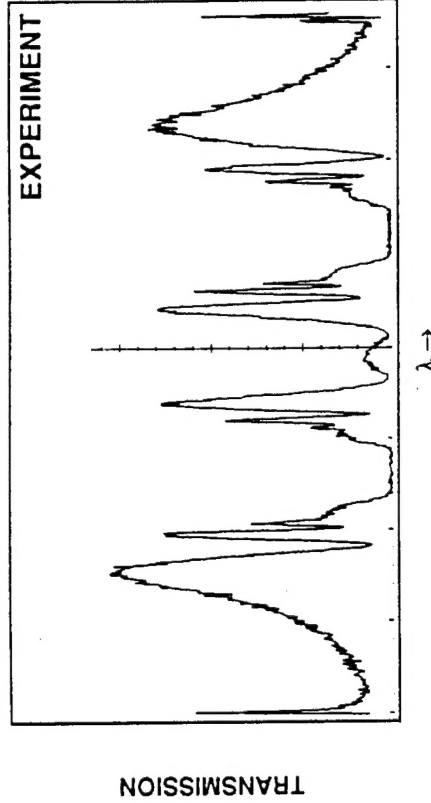


BLUE FARADAY FILTER SPECTRA ARE WELL PREDICTED UP TO 200° C

140° C, 200 G, 1 in.

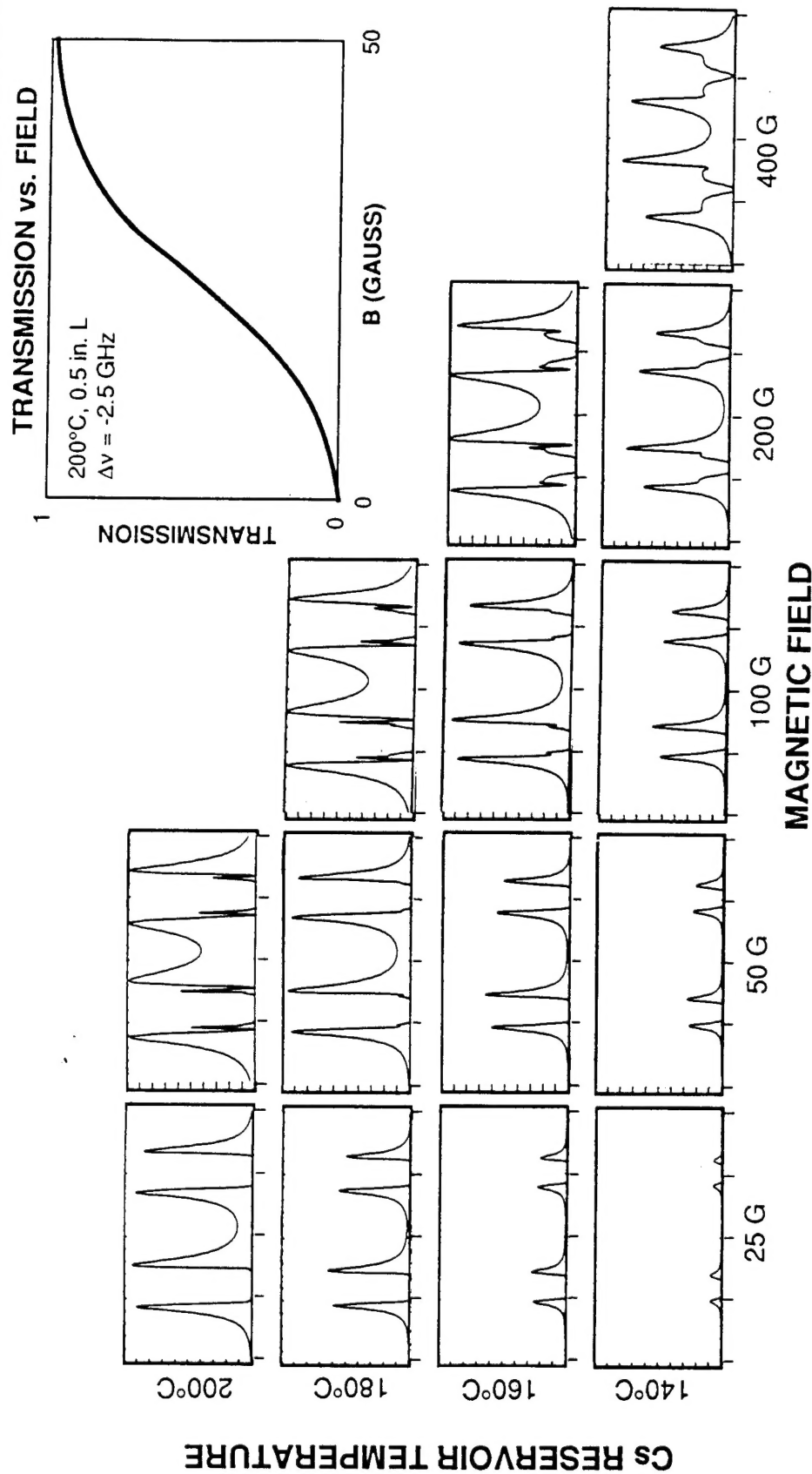


200° C, 200 G, 1 in.



- Optimum conditions minimize bandwidth and maximize transmission
- Modelling above 200° C must allow for collisional broadening
- Additional broadening becomes apparent at temperature $T \geq 200^\circ \text{C}$

GATING IS ACCOMPLISHED BY FIELD MODULATION

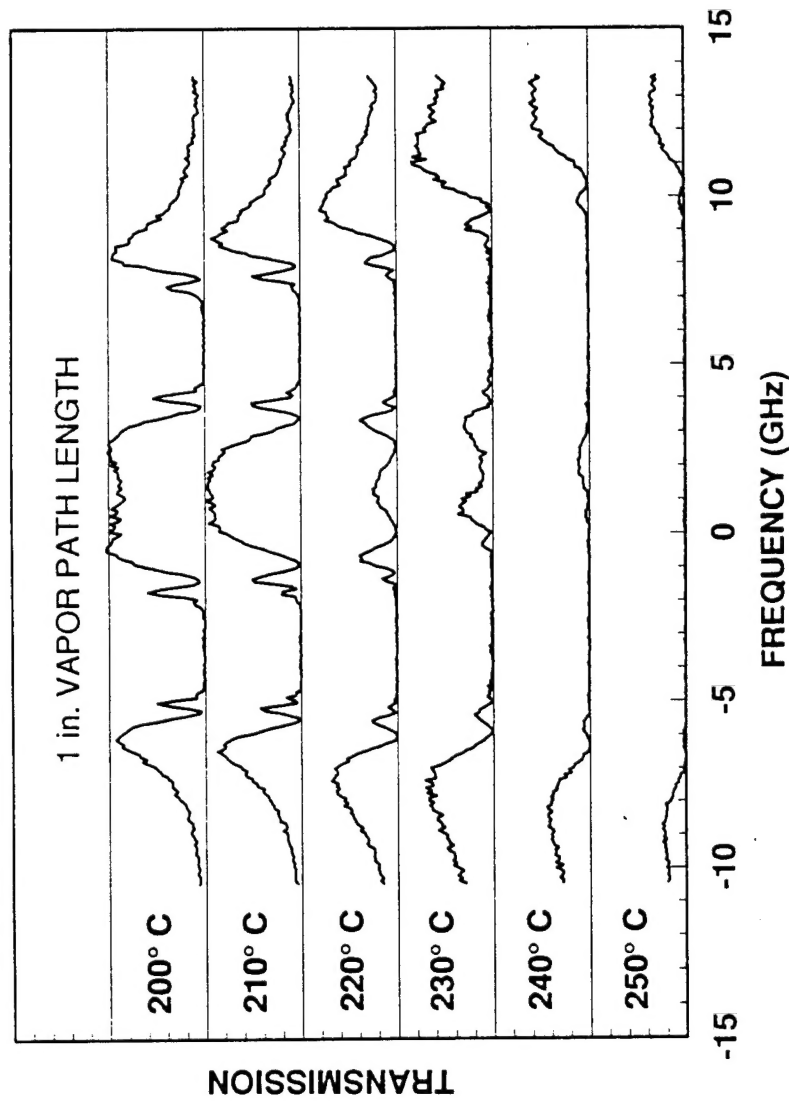


- Calculated blue Faraday filter spectra (0.5 in. L)
- Higher vapor temperatures can be traded for reductions in maximum magnetic field



THE FIELD REDUCTION FOR TEMPERATURE TRADE IS LIMITED BY TRANSMISSION DEGRADATION

BLUE FARADAY FILTER SPECTRA



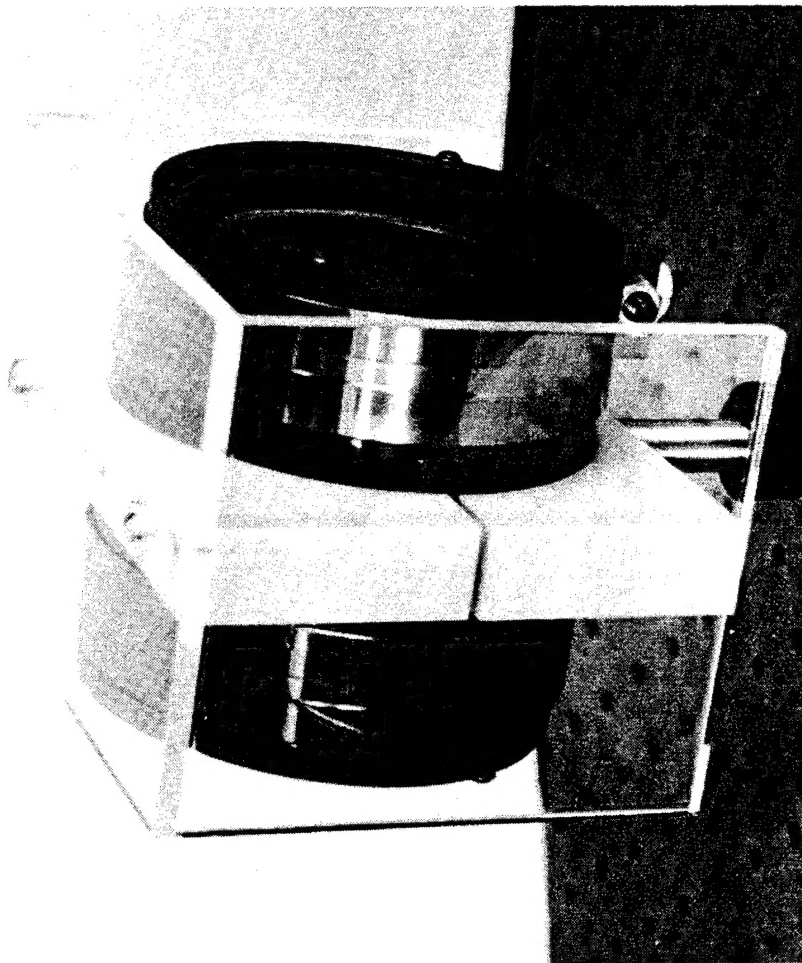
- Transmission spectra normalized by combined component transmission
- Increased collisional broadening at higher temperatures extends absorption line wings
 - Peak passband transmission is spoiled

FAST GATED FIELD GENERATION

- Requirements
 - 50 G longitudinal field
 - Uniform throughout active volume, 1 cm L x 5 cm ϕ ($\sim 2\%$)
 - Square pulse field modulation
 - risetime: 10 ns of nanoseconds
 - duration: $\gtrsim 1 \mu\text{s}$
- Pulsed coil implementation
 - Coil
 - single loop Helmholtz-like coils
 - Strip conductors for minimum inductance ($\sim 1/3 \mu\text{H}$)
 - 250 amp peak current for 50 gauss
 - Current supply
 - thyatron switched pulse forming network (PFN)
 - $\sim 600 \text{ ft}$ spool of 50Ω coax PFN
 - $< 35 \text{ kV}$ charge voltage

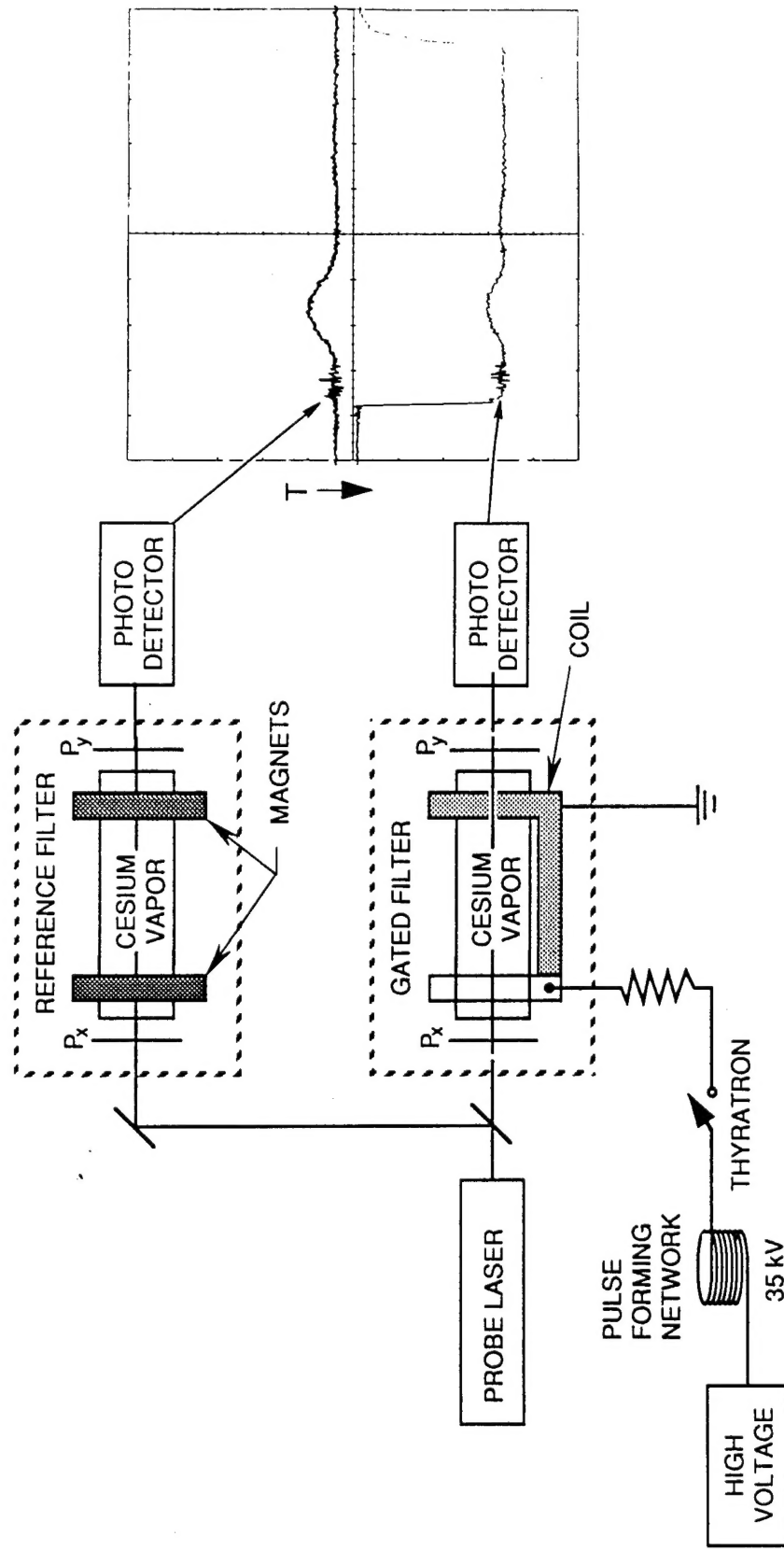


GATED CESIUM FARADAY FILTER



- Ultra-narrow bandpasses at 455, 459, 852 and 894 nm
- Unobscured 1 in. CA at angles up to 30° (2 in. CA at normal incidence)
- Out-of-band transmission (on axis) $\sim 10^{-5}$
- Open transmission (to polarized light) 32%

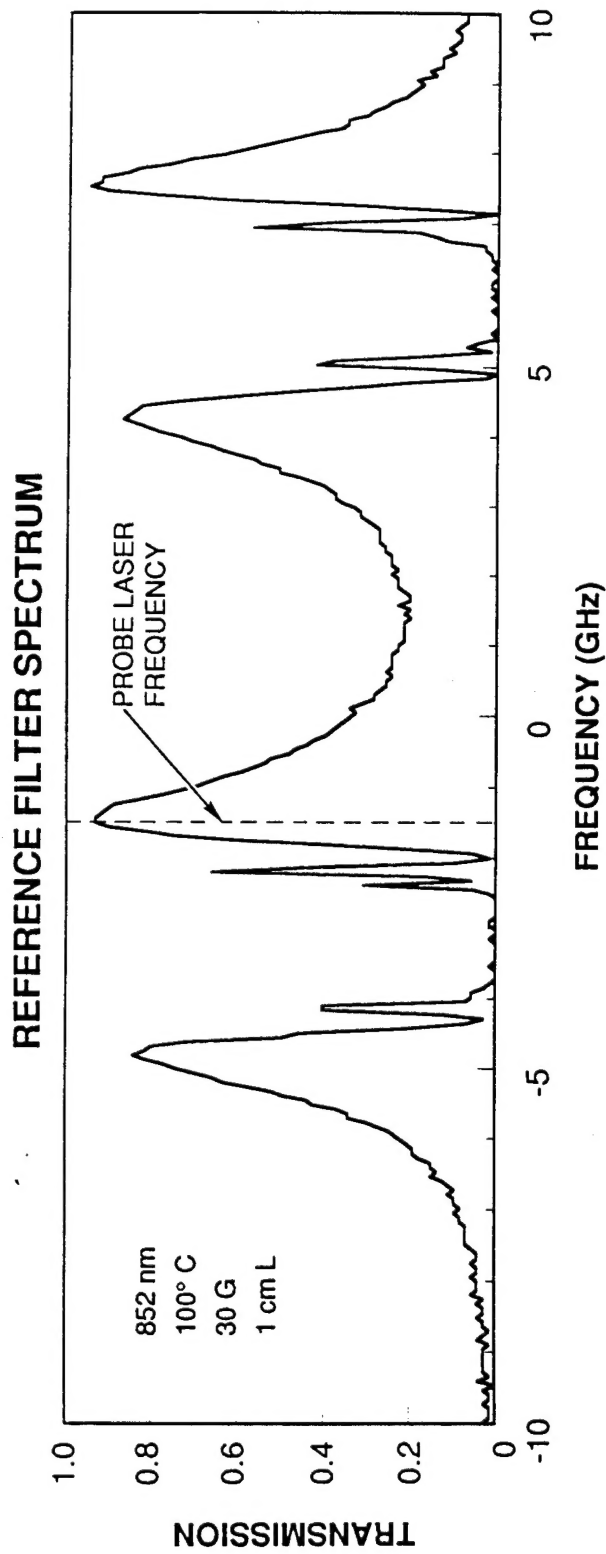
GATED FARADAY FILTER TEST SET-UP



- Gating was demonstrated for the near IR and blue passbands
 - NIR: Single mode diode laser at 852 nm
 - Blue: Single frequency dye laser at 455 nm
- Laser frequency stability was ascertained from reference filter transmission



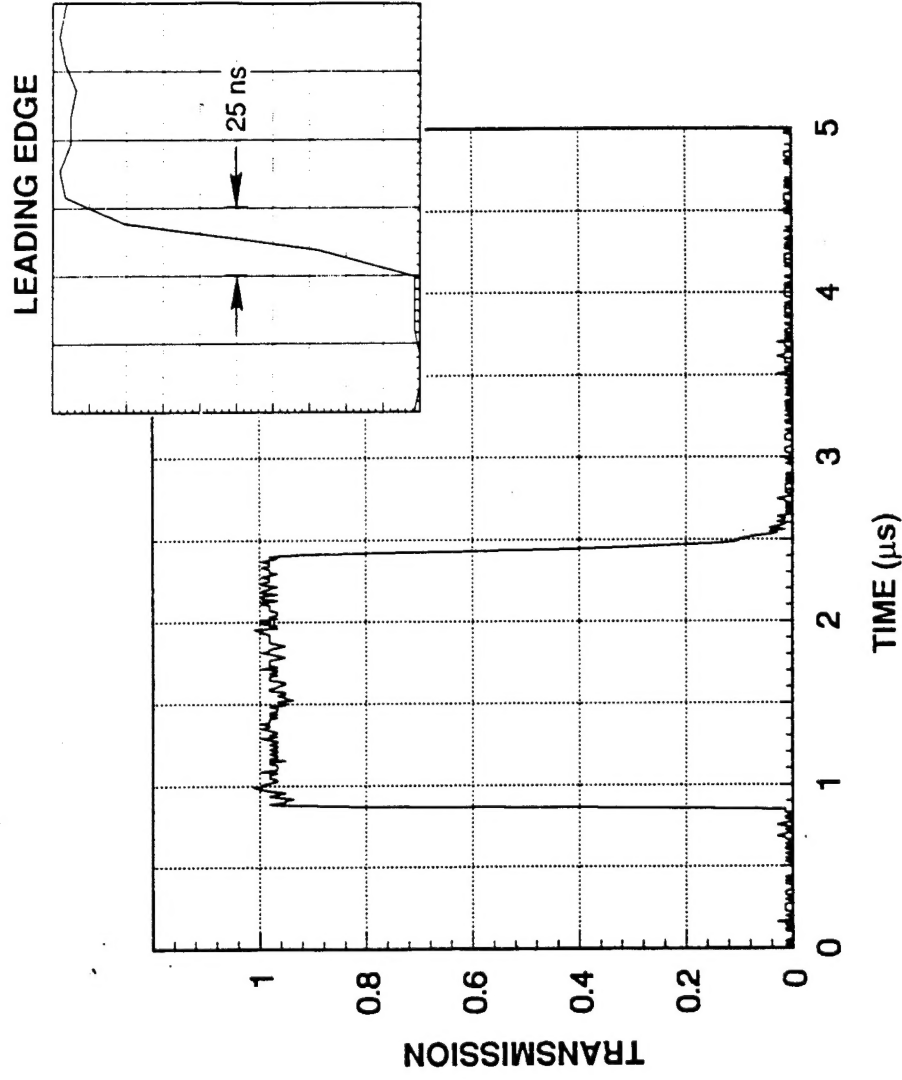
NIR GATED FARADAY FILTER TEST CONDITIONS



- Developmental testing is easier at 852 nm
 - Single mode diode laser probe
 - Lower temperature/field operating point
- Gated blue filter testing continues at NADC
 - Single frequency blue dye laser

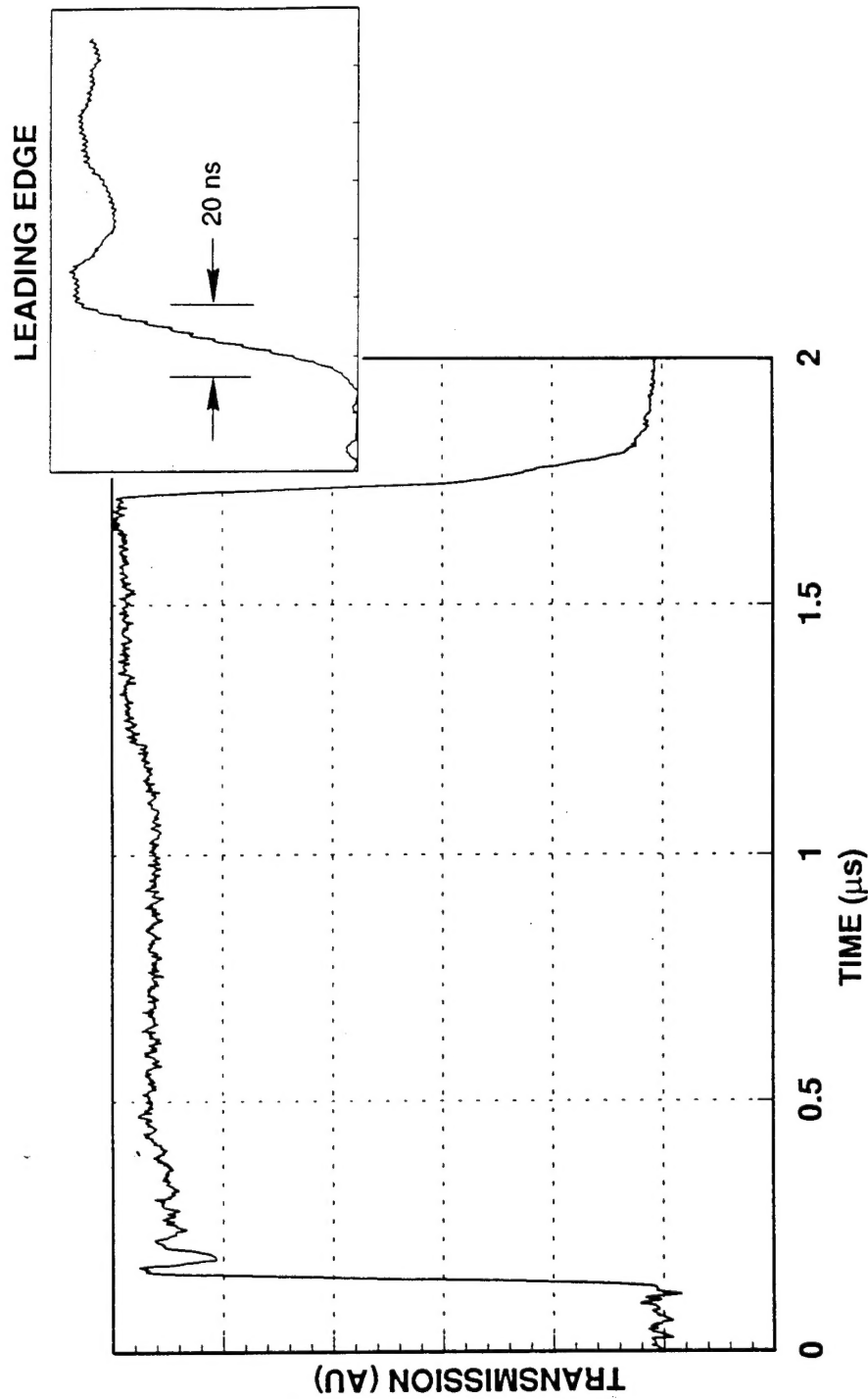


GATED NIR FARADAY FILTER TRANSMISSION



- Transmission with respect to peak passband transmission
- The sharp 20 ns risetime can be used to discriminate against nearby scattering

GATED BLUE FARADAY FILTER TRANSMISSION



- Replicates NIR result
- Absolute transmission measurements are in progress
- A faint blue glow, produced at high temperatures and fields, was observed and is under investigation (RF discharge?)

- The blue Cs Faraday atomic line filter was previously shown to provide ultra narrow, high transmission bandpasses with high background rejection
- The filter transmission may be modulated by varying the field, providing suppression of close range scattering
- The optimal operating vapor temperature of 200°C minimizes the field requirement while avoiding the collisionally broadened regime
- Gating tests at 852 nm and 455 nm demonstrated rapid 20-25 ns transmission risetimes in a 2" aperture, wide field-of-view filter